Radioactive Transport Modeling

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RESEARCH OBJECTIVES

The U.S. Department of Energy is actively investigating the technical feasibility of the permanent disposal of high-level nuclear waste in an appropriate repository to be situated in the unsaturated zone (UZ) at Yucca Mountain (YM), Nevada. The objectives of this study are to (a) evaluate the transport of radioactive solutes and colloids under ambient conditions from the potential repository horizon to the water table; (b) document the UZ Radionuclide Transport Model (RTM); and (c) determine processes and geohydrologic features that significantly affect radionuclide transport.

The most important factors affecting radionuclide transport are the subsurface geology and site hydrology, the presence of faults, fractures, and the relative distribution of zeolitic and vitric tuffs.

APPROACH

The RTM considers the site hydrology and the effects of the spatial distribution of hydraulic and transport properties in the YM subsurface. The migration and retardation of radionuclides are analyzed using the EOS9nT numerical code (Moridis et al., 1999) and the FRACL semianalytical code (Moridis and Bodvarsson, 1999). These codes account for the complex processes in the YM subsurface, and include advection, diffusion, hydrodynamic dispersion, kinetic or equilibrium physical and/or chemical sorption (linear, Langmuir, Freundlich or combined), first-order linear chemical reactions, radioactive decay and tracking of daughters, colloid straining, colloid physical-chemical filtration (equilibrium, kinetic or combined), and colloid-assisted solute transport.

RESULTS AND SIGNIFICANCE

The most important factors affecting radionuclide transport are the subsurface geology and site hydrology (Figure 1), i.e., the presence of faults (they dominate and control transport), fractures (the main migration pathways), and the relative distribution of zeolitic and vitric tuffs (CRWMS M&O, 2000). Diffusion from the fractures into, and subsequent sorption onto the matrix are the main retardation processes. Arrival times at the watertable increase with the sorption distribution coefficients of the various species, and may have to account for contributions from the decay daughters of certain radionuclides. Changes in future climatic conditions can have a significant effect on transport, as increasing infiltration leads to faster transport to the water table. The transport of colloids is strongly influenced by their size (as it affects diffusion into the matrix, straining at hydrogeologic unit interfaces and transport velocity) and by the parameters used in the kinetic filtration model. Different conceptual models of perched water at the site appear to have little effect on transport.

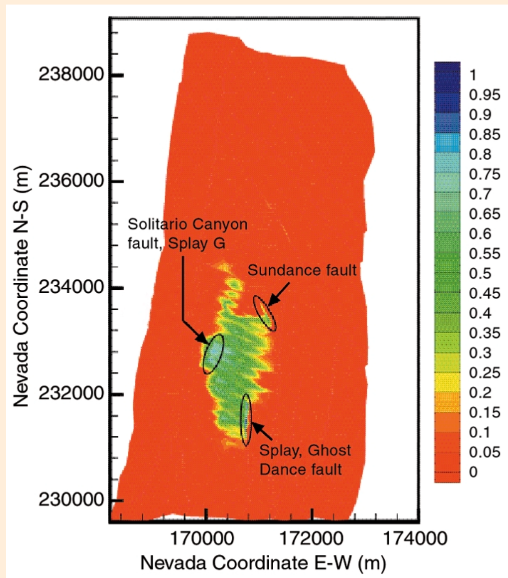

Figure 1. Relative concentration of the nonsorbing 99Tc in the fractures of the tsw39 layer below the potential repository at t=100 years of continuous release (CRWMS M&O, 2000). The importance of faults is evident.

RELATED PUBLICATIONS

Moridis, G., and Q. Hu, Radionuclide transport models under ambient conditions, MDL-NBS-HS-000008, Las Vegas, Nev., CRWMS M&O, 2000.

Moridis, G.J., and G.S. Bodvarsson, Semianalytical solutions of radioactive or reactive tracer transport in layered fractured media, Berkeley Lab Report LBNL-44155, 1999.

Moridis, G.J., Y.S. Wu and K. Pruess, EOS9nT: A TOUGH2 module for the simulation of water flow and solute/colloid transport in the subsurface, Berkeley Lab Report LBNL-42351, 1999.

ACKNOWLEDGEMENT

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